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EXAMINER	
RUGGLES, JOHN S	
ART UNIT	PAPER NUMBER
1756	

SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	04/27/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

Office Action Summary	Application No.	Applicant(s)	
	10/730,533	CHANG ET AL.	
	Examiner	Art Unit	
	John Ruggles	1756	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08 March 2007*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,3-7 and 9-16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,3-7 and 9-16* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination (RCE) under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicants' submission filed on 3/8/07 has been entered.

Response to Amendment

In the current 3/8/07 submission, claims 1, 9-10, and 16 are currently amended, claims 2, 8, and 17-22 remain as previously canceled, and claims 3-7 and 11-15 remain as previously or originally presented. Therefore, only claims 1, 3-7, and 9-16 remain under consideration.

The previous objections to the title and the abstract, as well as the previous new matter objection to the specification (corresponding to the previous new matter rejection of instant claims under the first paragraph of 35 U.S.C. 112) are each withdrawn in view of the current amendment.

The previous specifically exemplified objections to the specification numbered (5)-(7) are also withdrawn in view of the current amendment. However, *additional specific examples* of reasons for further objection to the specification are listed below.

The previous objections of claims 9-16, the previous new matter rejection of claims 1 and 3-7 under the first paragraph of 35 U.S.C. 112, and the previous rejection of claims 9-16 under the second paragraph of 35 U.S.C. 112 are each withdrawn in view of the current amendment.

The previous art rejections of the instant remaining claims under 35 U.S.C. 102(e)/103(a) and 103(a) are maintained in revised form along with new rejections set forth below, as necessitated by the current amendment and accompanying remarks.

Responses to Applicants' current arguments are presented after the first rejection or objection to which they are directed. Rejections or objections of the previous Office action not found below are withdrawn in view of the current amendment and accompanying remarks.

Specification

The disclosure is still objected to because of *at least the following exemplary informalities*: (8) in [0023] lines 3-6, the sentence "In order to form...as long as photolithography technology allows." appears to be an incomplete sentence that should be clarified; (9) in [0021] line 1, "number of annular rings" should be corrected to --the number of annular rings--, in reference to the number of annular rings described in the immediately preceding paragraph [0020]; and (10) in [0023] lines 8 and 9-10, "can result to" (in line 8) should be changed to --can result [[to]] in-- and "two times of the" should be shortened to --two times [[of]] the--.

Appropriate correction is again required.

Claim Rejections - 35 USC § 102/103

The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

Claims 1 and 3-7 are rejected under 35 U.S.C. 102(e) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Sivakumar et al. (US 2004/0101765).

Sivakumar et al. teach chromeless phase shift lithography (CPL) masks (chromeless PSMs) and methods of using them for patterning large line/space geometries (title, abstract). CPL masks have adjacent transparent 0° non-PS regions and 180° PS regions to generate a phase edge between the PS and non-PS regions that is darkened in the resist aerial image by destructive interference of light diffracted from the 0° and 180° regions immediately on either side of the phase edge (paragraph [0003], *instant claims 3, 5, and 7*). The PS features can be recesses or mesas patterned on a quartz mask substrate (*instant claim 6*, e.g., by etching, etc. [0026]). Figure 6D (Option D) shows a chromeless PSM having a "bull's eye" configuration including a central PS square portion 604 that is surrounded by a first annular non-PS ring 608, which is further surrounded by another outer annular PS ring 606 [0029]. This Figure 6D chromeless PSM is very similar to that shown by instant Figure 1A. The interspersed or alternating PS and non-PS regions (including the central square and surrounding annular rings that make up an annular PS pattern) are each physically small enough and placed close enough together to ensure that the aerial images of the individual features merge to provide a combined aerial image capable of patterning a large resist structure ([0030], that is darkened or unexposed on the resist, reading on *instant claim 4*). The way 604, 608, and 606 are drawn in Figure 6D further suggests that these annular or concentric rings have similar or equivalent widths, which would therefore appear to represent an equal line space PS pattern. To produce an ideal deep single minimum aerial image intensity on a resist using 193 nm exposure light, the phase edge separation or the line width on the chromeless PSM should be 0.1μm (100nm [0004], corresponding to a pitch on the mask (Pm) of 200nm for PS lines separated by an intermediate non-PS line of the same width as the PS lines). An exemplary modern integrated circuit (IC) has lines with a base width (or critical

dimension, CD) of 0.25μm (250nm) or other features such as pads having larger widths [0025], corresponding to a resist image (e.g., on a semiconductor substrate, etc.) having a pitch (Pcs) of 500nm or larger). Applying Pm = 200nm and Pcs ≥ 500nm for a common 4X mask (N=4) to the expression Pm < N x 2Pcs (for a mask pattern pitch smaller than two times a corresponding critical dimension pitch on a semiconductor substrate as instantly claimed) would yield the following: 200nm < 4 x 2 (500nm) or 200nm < 4,000nm (reading on *instant claim 1*). Therefore, one of ordinary skill in the art at the time of the instant invention would have a reasonable expectation of success in patterning a resist by a chromeless PSM having an annular equal line space PS pattern with a mask pitch (Pm, e.g., 200nm, etc.) that is smaller than two times a corresponding CD pitch (Pcs, e.g., 500nm, etc.) on a semiconductor substrate. In fact, a chromeless PSM having a suitable pattern of interspersed or alternating PS and non-PS regions (including a central square and surrounding annular rings that make up an annular equal line space PS pattern) that are each physically small enough and placed close enough together to ensure that the aerial images of the individual features merge to provide a combined aerial image would be inherently capable of forming a large area resist pattern or structure (as taught by Sivakumar et al.).

On pages 11-16 of the current amendment, Applicants acknowledge the illustration of the "bull's eye" annular PS pattern in Figure 6D taught by Sivakumar et al., but argue that Sivakumar et al. do not specifically require that the annular PS/non-PS lines in Figure 6D have equal line widths. However, it is still believed that one of ordinary skill in the art would have recognized the annular PS pattern shown in Figure 6D of Sivakumar et al. to fairly suggest the utility of equal line spacing in this annular PSM, because each of the PS/non-PS lines would

have to be physically small enough and placed close enough together to ensure that the aerial images of the individual features merge to provide a combined aerial image capable of patterning a large resist structure that is all darkened or unexposed on the resist (as taught by Sivakumar et al. and discussed previously, as well as being repeated above). As also indicated above, the way 604, 608, and 606 are drawn in Figure 6D of Sivakumar et al. further suggests to one of ordinary skill in the mask art that these annular or concentric rings have similar or equivalent widths, which would therefore appear to represent an annular equal line space PSM pattern. Nevertheless, a new obviousness rejection under 35 U.S.C. 103(a) with additional alternative references is set forth below to further address Applicants' arguments against equal line spacing in the Sivakumar et al. chromeless annular PSM pattern shown by Figure 6D.

Claims 1 and 3-7 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sivakumar et al. (US 2004/0101765) in view of either Kim (US 5,756,235) or Chen et al. (US 6,335,130).

While teaching a chromeless annular line space PSM in Figure 6D, Sivakumar et al. as discussed above does not specifically require that the PS and adjacent non-PS annular lines in Figure 6D have equal line widths.

However, it is common in the mask art to employ line and space patterns on a PSM in which both the lines and the directly adjacent spaces have the same or equal widths. For example, Kim (US 5,756,235) in claims 2, 7, 9, and 14 requires the same width for the lines and the adjacent interval openings (spaces) between the lines on a PSM (c5/L57-c6/L57), meaning that this PSM has an equal line space pattern. Alternatively, Chen et al. (US 6,335,130)

specifically teach the use of "an equal line space chromeless pattern" of a chromeless shifter-shutter PSM having primary features 1702, as shown in Figure 17(A) (c13/L50-55).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention in the chromeless annular line space PSM of Figure 6D (as taught by Sivakumar et al.) to have made the PS and adjacent non-PS annular lines in Figure 6D with equal line widths, because it is common in the mask art to employ line and space patterns on a PSM in which both the lines and the directly adjacent spaces have the same or equal widths (as taught by either Kim or Chen et al.). In fact, ensuring that the PS and adjacent non-PS annular lines in Figure 6D of Sivakumar et al. have equal line widths would have been especially obvious to one of ordinary skill in the art, because each of the PS/non-PS lines would have to be physically small enough and placed close enough together to ensure that the aerial images of the individual features merge to provide a combined aerial image capable of patterning a large resist structure that is all darkened or unexposed on the resist (as taught by Sivakumar et al. and discussed previously, as well as being repeated above, *instant claims 1 and 3-7*).

In response to Applicants' argument on pages 13-16 (especially on pages 15-16) of the current amendment that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971). In this case, the prior art rejections presented above rely on knowledge that was within the level

of ordinary skill at the time of the claimed invention, but these prior art rejections do not depend on knowledge gleaned only from Applicants.

On pages 14-16 of the current amendment, Applicants contend that the relationship between the mask pitch and the corresponding critical dimension (CD) pitch on a patterned semiconductor substrate taught by Sivakumar et al. does not exactly match the full range of this relationship as instantly claimed. However, the prior art does not have to teach the entire range of this relationship, but rather only needs to show at least one example or portion within this range in order to read on the instant claims. Equally spaced lines and spaces that are ideally each 100nm wide on the Sivakumar et al. chromeless annular line and space PSM would correspond to a mask pitch (Pm) of 200nm and a modern IC (e.g., on a semiconductor substrate, etc.) having plural lines with a base width (CD) of 250nm or larger would correspond to a CD pitch on the semiconductor substrate (Pcs) of 500nm or larger. This reads on the instant requirement that the mask pitch (Pm) of 200nm is smaller than two times the CD pitch on the semiconductor substrate (2Pcs, 200nm < 1,000nm), even without accounting for reduction exposure optics (e.g., N=4 for a common 4X mask, etc.). Additional application of the reduction factor N=4 would lead to the expression Pm < N x 2Pcs (200nm < 4,000nm).

Therefore, it is still held that the chromeless annular line and space PSM in Figure 6D (as taught by Sivakumar et al.) would have been recognized by one of ordinary skill in the art as being inherently capable of meeting the instant requirement of a mask pitch that is smaller than two times a corresponding CD pitch on a semiconductor substrate. Also, it would have been obvious to make the chromeless annular line and space PSM taught by Figure 6D of Sivakumar et al. so that the PS/non-PS lines and spaces are equally spaced on the chromeless annular line

and space PSM, because it is common in the mask art to employ line and space patterns on a PSM in which both the lines and the directly adjacent spaces have the same or equal widths (as taught by either Kim or Chen et al.). In fact, ensuring that the PS and adjacent non-PS annular lines in Figure 6D of Sivakumar et al. have equal line widths would have been especially obvious to one of ordinary skill in the art, because each of the PS/non-PS lines would have to be physically small enough and placed close enough together to ensure that the aerial images of the individual features merge to provide a combined aerial image capable of patterning a large resist structure that is all darkened or unexposed on the resist (as taught by Sivakumar et al. and discussed above, *instant claims 1 and 3-7*).

Claims 9-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sivakumar et al. (US 2004/0101765), either alone or in view of either Kim (US 5,756,235) or Chen et al. (US 6,335,130), and in view of either Dao et al. (US 5,302,477) or Schroeder et al. (US 2003/0027057).

While teaching other aspects of the instant claims including selective etching of an annular equal line space pattern in a quartz substrate for making a chromeless PSM, as discussed above, Sivakumar et al. (either alone or in combination with either Kim or Chen et al.) do not specifically teach patterning a resist layer on the PSM substrate before etching through the patterned resist layer and removing the remaining resist layer after etching (*instant claim 9*). Also, Sivakumar et al. (either alone or in combination with either Kim or Chen et al.) do not specifically teach using a conductive chrome layer (e.g., as an etching mask, etc.) between the PSM substrate and the patterned resist to manufacture the PSM (*instant claim 10*).

Dao et al. teach an inverted phase-shifted reticle or mask (PSM) having adjacent inverted phase features with PS rims or phase edges between 0° and 180° phase features; and methods of fabricating the PSM (title, abstract). The methods of fabricating the PSM include performing patterning or etching of a (conductive) chrome (Cr) mask layer 21 (*instant claim 12*) formed on a transparent quartz substrate 20 (as shown in Figure 7, *instant claim 11*) through an overlying patterned photoresist or resist layer 51, patterning or etching of the quartz substrate 20 through the patterned Cr 21, and removing remaining resist layer 51 (as shown in Figure 8, c8/L46-69). A remaining portion of the Cr 21 is also removed (as shown in Figures 9 and 10, which is a cross-sectional view of the annular ring patterned PSM shown in Figure 5A, c9/L9-12, *instant claim 10*). An alternative method includes directly etching the PSM transparent quartz substrate 20 through an overlying patterning layer 125 (e.g., of resist, etc.) followed by removal of the remaining patterning layer or resist layer 125 (as shown in Figures 27 and 28, c11/L36-57, *instant claim 9*).

Schroeder et al. teach a phase shift mask 400 (PSM) and method of manufacturing the PSM (abstract). Figure 6A shows a PSM 400 having a transparent quartz substrate 402 (*instant claim 11*) with a first etched region 458 for a 180° phase feature and adjacent second unetched region 460 for a 0° phase feature (paragraphs [0041-0047]). In the method of manufacturing the PSM, a (conductive) chrome (Cr) layer 404 (*instant claim 12*) is preferably formed on the transparent substrate and patterned before etching of the underlying transparent substrate [0043]. The method for making the PSM in Figure 6A would be expected to involve patterning of an opening in the Cr layer through an overlying patterning layer (e.g., of resist, etc.), removal of the remaining patterning layer or resist layer, etching of the underlying transparent substrate at a first

region 458 through the opening in the Cr layer, and removal of a remaining portion of the Cr layer that forms a second adjacent region 460 (*instant claim 10*). Alternatively, the method of making the PSM can exclude the use of a Cr layer 404 ([0043] lines 4-5, which suggests that the PSM transparent quartz substrate 402 can be etched directly through an overlying patterning layer (e.g., of resist, etc.) followed by removal of a remaining patterning layer or resist layer, *instant claim 9*).

It would have been obvious to one of ordinary skill in the art at the time of the invention to manufacture a chromeless PSM including a central portion and surrounding annular rings that make up an annular equal line space PS pattern having a mask pitch that is smaller than two times a corresponding CD pitch on a semiconductor substrate (taught by Sivakumar et al. either alone or in combination with either Kim or Chen et al., as discussed above) by etching PS features between non-PS features into the transparent substrate of the chromeless PSM either directly through an overlying patterned resist or indirectly through an overlying patterned resist and intermediate patterned or etched Cr layer, as exemplified by either Dao et al. or Schroeder et al. This is because both of these direct and indirect etching methods for manufacturing etched phase shifters in a transparent mask substrate to make a PSM have been well known for their advantages in the art for some time, as exemplified by either Dao et al. or Schroeder et al. (*instant claims 9-15*).

Claim 16 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sivakumar et al. (US 2004/0101765), either alone or in view of either Kim (US 5,756,235) or Chen et al. (US 6,335,130), and in view of Lee et al. (US 5,240,796).

While teaching other aspects of *instant claim 16* including selective patterning of an annular equal line space pattern on a quartz substrate for a chromeless PSM having a mask pitch that is smaller than two times a corresponding CD pitch on a semiconductor substrate (as discussed above), Sivakumar et al. (either alone or in combination with either Kim or Chen et al.) do not specifically teach disposing added phase shifting (PS) material on the mask substrate through a patterned conductive layer (e.g., as a coating mask, etc.).

However, Lee et al. teach a method that has been known for some time to fabricate a chromeless phase shift reticle or mask (chromeless PSM) having a pattern of added PS material portions at a thickness to achieve a PS of 180° for light passing through the PS portions relative to light transmitted through non-PS (0°) portions of the transparent mask substrate (title, abstract, issue date). The method includes depositing a conductive or metallic layer 40 (e.g., of Cr, etc.) on a transparent mask substrate 30 (e.g., of quartz, etc.), forming a photoresist or resist layer 44 on the conductive Cr layer (as shown in Figure 3A, c4/L61 to c5/L38), patterning the resist layer 44, anisotropic dry etching of the Cr layer to form patterned portions 48 with openings 46 having vertical sidewalls, and removing the remaining resist layer 44 (as shown in Figure 3B, c5/L38-51). Next, a PS material 50 (e.g., of silicon dioxide (SiO_2), silicon nitride (SiN), etc.) is blanket or conformally deposited on the patterned conductive Cr layer 48 to fill the openings 46 therein (as shown in Figure 3C, c5/L52 to c6/L7). Then, the PS material 50 is planarized down to the same thickness as the patterned conductive Cr layer 48 (as shown in Figure 3D, c6/L8-13) followed by etching away the patterned conductive Cr 48 to form patterned PS portions 52 having vertical sidewalls with intervening transmissive areas 54 on the transparent mask substrate (as shown in Figure 3E, c6/L29-37, which reads on *instant claim 16*).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to manufacture a chromeless PSM including a central portion and surrounding annular rings that make up an annular equal line space PS pattern having a mask pitch that is smaller than two times a corresponding CD pitch on a semiconductor substrate (taught by Sivakumar et al. either alone or in combination with either Kim or Chen et al., as discussed above) by patterning added PS features (instead of etching PS features) between non-PS features on the transparent substrate of the chromeless PSM through an overlying patterned resist and an intermediate patterned or etched temporary conductive Cr layer as a coating mask, because this would reasonably be expected to achieve vertical sidewalls for added PS features on the chromeless PSM (which has been known in the art of making chromeless PSMs for some time, as taught by Lee et al.).

Response to Arguments

Applicants' arguments with respect to the instant claims have been considered, but they are either moot or unpersuasive in view of the new and maintained ground(s) of objection and rejection set forth in this Office action. Specific responses to current arguments by Applicants are presented above, after the first rejection or objection to which they are directed.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Ruggles whose telephone number is 571-272-1390. The examiner can normally be reached on Monday-Thursday and alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Huff can be reached on 571-272-1385. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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